3D Shape Design - Surface Area, Volume, and Density

Name :_____

Date: _____

1. **Hypothesis:** What type of 3D shape design will *maximize the volume* if all shapes have the same amount of surface area?

_____

_____

_____.

2. **Investigation:**

Materials needed:
- Construction Paper
- Scissors
- Scotch Tape
- Ruler
- Popcorn & Bowls/Cups
- Colored Pencils
- Graph Paper

Procedures & Data Collection:

1.) Review the activity terms / goals (watch the '*Simpsons"* video clip) before students will form groups of 3-4.
2.) Each group will acquire supplies, making sure that each student has their own sheet of construction paper (*a single piece ONLY!)*
3.) Each group will design *different* 3-dimensional objects with approximately the same surface area (the piece of construction paper) *(i.e. cone, cylinder, cube, etc)*
4.) Within each group, the volume of each object created will be tested by filling it with popcorn. Students will identify the object with the greatest volume.
5.) Students will then verify their popcorn measurements by finding the volume and surface area of their objects using the geometric formulas. *All students will complete section 3.*
6.) Each group will present the shape in their group that had the greatest volume and compare it to other groups. The winning group is awarded the 'treasure'
7.) The instructor will review and show example of the use of *substitution* and students will apply this method to further understand the relationship between object dimensions, surface area, and volume of cylinders (*similar to the tubes for SeaPerch Robots). Section 4 as homework, if time does not allow completion.*

8.) *Optional Extensions included in lesson slides.*

3. Analysis

1. Describe the 3D polygon that you decided to make. If it is regular, give it's name (i.e. cone). If it is irregular, try to describe it the best you can.

2. Once you and your group have designed your 3D shapes, report which shape held the most popcorn. Can you think of a way to do this other than counting each individual popcorn kernel?

Formulas for Surface Area and Volume of 3D Figures

Name	Surface Area	Volume
Rectangular Prism	$SA = 2(lw + wh + lh)$	$V = lwh$
Cylinder	$SA = 2\pi r^2 + 2\pi rh$	$V = \pi r^2 h$
Cone	$SA = \pi r^2 + \pi rl$	$V = \frac{\pi r^2 h}{3}$
Sphere	$SA = 4\pi r^2$	$V = \frac{4\pi r^3}{3}$
Square Pyramid	$SA = b^2 + 2bl$	$V = \frac{b^2 h}{3}$

3. To verify your findings, you will measure the surface area and volume of each object. *Write the formulas* you will use.

4. Measure the dimensions of your object. *Report the length (l), width (w), height (h), and radius (r)*, if necessary in centimeters (cm).

5. Solve the formulas by plugging in your measured dimensions. Report the surface area and volume of the shape you made.

Surface Area:

Volume:

6.) Even though everyone in your group used a single sheet of construction paper, there may be some differences in surface area. Why might this be? What are possible sources of error?

4. **Cylinder Dimensions and Maximizing Volume**:

Radius (cm)	Height (cm)	Volume (cm^3)	Surface Area (cm^2)
1			375
2			375
3			375
4			375
5			375
6			375
7			375
8			375

1. Which formula will you use to find the height of each cylinder?

2. Using algebra, calculate the height of each cylinder with the given radius and surface area. Working in your group, you can split up the tasks, but *each student must show their work for at least 2 of the given radii*. Fill in the 'height' column of the table (above).

3. Calculate the volume of each cylinder once you have found the height. Again, *show work for at least 2 of cylinders*, so I can see that each member of the group is contributing. Remember that volume is measured in cubic centimeters (cm^3).

4. Do you notice any patterns between the relationship of height, radius, and volume? Which radius gives you the greatest volume? Did any radius measurements give you a strange answer? Why might that be?

5. Do you think the radius value that gave you the largest volume is actually the maximized volume for a cylinder with a 375 cm^2 surface area?

6.) *Connections Question*: Why is understanding the volume and dimensions of cylinders important when designing your SeaPerch underwater robot? What other aspects of your robot are also critical to determining if it will sink / float?